NATURAL ATTENUATION OF EXPLOSIVES IN GROUNDWATER AT ARMY SITES

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Abstract

Cleanup of groundwater contaminated with explosives can be prohibitively expensive. Achieving regulatory limits when concentrations reach low levels is often especially difficult. Natural attenuation may be an attractive alternative to available remediation technologies at sites that meet well-defined selection criteria, acceptable risk levels, and that satisfy specific regulatory concerns. The objectives of this project are to demonstrate that attenuation of explosives can be established through appropriate site monitoring, to develop guidance for selection of natural attenuation as a remediation alternative, and to develop a protocol for establishing a site monitoring plan and point(s) of compliance. The protocol for implementation of natural attenuation will be developed from data gathered from at least one site exhibiting explosives contaminated groundwater. An initial data gathering step will include a synthesis of what is known concerning degradation processes, contaminant transport and site geology/hydrology. Existing data will be supplemented by appropriate field investigations. The final protocol will describe selection criteria and considerations, an approach to site characterization and monitoring, parameters to assay and analytical methods, and establishment of points of compliance.

INTRODUCTION

Research has demonstrated that certain explosives are naturally immobilized in soil systems under specific environmental conditions[1]. Explosives are also degraded by microbial and/or abiotic processes[2, 3, 4]. Any of these sets of processes may provide evidence of attenuation in the subsurface. Furthermore, the hydrologic and geologic dynamics of the site groundwater together with the location and risk associated with potential contaminant receptors may also provide support for selecting natural attenuation as a remediation alternative. If the site is isolated making receptors far removed, and/or if the groundwater flow is extremely slow, risk to receptors may be deemed acceptable.

Natural attenuation is not a "no action" remediation alternative. Selection of natural attenuation requires a thorough understanding of relevant site hydrology, geology, and the contaminant plume. Natural attenuation also requires long-term site monitoring to assure that receptors are being protected and that no detrimental changes in projected contaminant migration toward receptors have occurred. The objectives of this study are to provide guidance to site personnel for selection of natural attenuation as a remediation alternative, for monitoring the site for prolonged protection and regulatory compliance, and for eventual site closure.

Natural attenuation has been defined as "the reduction of contaminant concentration to environmentally benign levels through natural processes"[5]. Active processes include, but are not limited to, advection, dispersion, diffusion, volatilization, biotic degradation (mineralization and transformation), sorption/desorption, ion

exchange, complexation, abiotic transformation, and plant and animal uptake. This definition excludes any intervention to enhance natural processes.

Studies of natural attenuation for petroleum hydrocarbons by the Air Force in cooperation with EPA have contributed significantly to maturation of the technology[6, 7, 8, 9, 10, 11, 12, 13]. Natural attenuation of BTEX has also been investigated at several sites: Sleeping Bear Dunes, MI[14, 15]; Sampson County, NC[15]; Rocky Point, NC[15]. At least three states have developed guidelines for permitting natural attenuation, Wisconsin[16, 17, 18], Florida[19, 20] and Michigan[21].

TECHNICAL DESCRIPTION

Site Selection and Characterization

An ideal candidate site for demonstrating natural attenuation is one in which the groundwater has (1) sufficient residence time to allow natural attenuation processes to occur, (2) limited or no risk of contamination of local receptors, e.g. drinking water wells, streams, wetlands, and (3) a receptive local/regional regulatory community. We selected the Louisiana Army Ammunition Plant at Bossier City, Louisiana as our initial demonstration site for these and several other reasons. The source of contamination, several liquid waste storage lagoons, was removed six years ago. Absence of an active source of contamination will simplify the interpretation of the groundwater data and the plume migration. The site has been extensively characterized in terms of geology, hydrology and contamination in soils and groundwater. The area of interest already has over 50 groundwater monitoring wells; therefore, cost for installation of wells will be minimal. Contaminant data for many of these wells is available for each year since remediation of the lagoons. Region VI of the EPA has been receptive to considering natural attenuation as a remediation alternative for the site.

Although this demonstration site has received extensive characterization, we hope to develop procedures for site characterization that will minimize the cost of implementing site characterization for future users. We anticipate a need for good geology, hydrology and contaminant data that focus on the objectives of natural attenuation. An objective of the study is to define an efficient, cost-effective sampling protocol.

To justify selection of natural attenuation, the site must be sufficiently characterized to support the following performance criterion: The rate of contaminant immobilization/degradation is sufficient to protect the nearest possible receptor over a "reasonable" period of time. The definition of "reasonable" will usually be in terms of local risk assessments and regulatory concerns.

Monitoring

A site monitoring plan consisting of monthly sampling of 30 existing wells has been initiated. Monthly sampling will occur for the first six months of the project only. After that, sampling will occur quarterly for the remainder of a two year period. The monthly sampling will allow us to refine sampling protocols, identify sources of variability and determine the degree of variability in the site. Parameters that will be monitored initially include the following: explosives and their transformation products, potential electron acceptors (iron, manganese, sulfate, nitrate/nitrite), dissolved oxygen, conductivity, pH, total dissolved solids, and water level.

Modeling

A three-dimensional, multi component transport code is under development to describe and predict the subsurface fate of explosives. While code preparation is being conducted on a Unix workstation platform; eventual migration to other platforms (personal computers to multi processor systems) is anticipated. Long-range plans include bringing a mature version of this code into the DoD Groundwater Modeling System (GMS), a standard user interface with which to visualize simulation input/output. Available GMS tools will be used to visualize hydrogeology, monitoring well data, and model predictions.

Guidance Document

A user-friendly guidance document will be prepared for use by facilities personnel and others who must consider natural attenuation as a remediation alternative. The document will include pertinent site characterization guidance, monitoring protocols, selection of compliance criteria, and guidance on site closure.

CONCLUSIONS

Natural attenuation of explosives will be demonstrated at Louisiana Army Ammunition Plant in order to develop guidance on selection and implementation of natural attenuation as a remediation alternative. The demonstration will proceed through a comprehensive groundwater monitoring plan, adoption of a groundwater model and preparation of an implementation protocol.

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